

4. EVALUATION OF ADDITIONAL GROUNDWATER SITE REMEDY ALTERNATIVES

4.1 General

The FSTM screened 20 groundwater remedy alternatives [GeoSyntec, 2003b]. Lehigh determined that five alternatives passed the screening criteria and recommended that they be evaluated more extensively in the FSTR. After its review of the FSTM, Ecology recommended that the FSTR also include source abatement alternatives (i.e., Additional Source Control and Partial Source Removal¹¹). The FS process, which included further discussions with Ecology, led to the inclusion of two more alternatives. It also led Lehigh to drop one alternative from further consideration and to consolidate three technologies into a single alternative. Accordingly, the following alternatives are evaluated in this Revised dFSTR – See Exhibit ES-3.

- Alternative #1 – Permeable Treatment Wall (PTW)
- Alternative #2 – Pump and Treat (P&T)
- Alternative #3 – Additional Source Control (ASC)
- Alternative #4 – Partial Source Removal (PSR)
- Alternative #5 – Funnel and Gate Treatment (FGT)
- Alternative #6 – Partial Additional Source Control (PASC)

Section 4 presents descriptions of each of the six alternatives. The descriptions begin with features that are common to each of them, such as institutional controls, followed by the essential features of each alternative and the advantages and disadvantages of the alternative relative to each of the evaluation criteria identified in Section 3. As described in Section 3, each alternative is evaluated against the threshold requirements, other requirements, disproportionate cost analysis criteria, and the 1999 AO criteria. For purposes of the disproportionate costs analysis, Alternative # 4 – PSR, is used as the baseline remedy since it exhibits the highest degree of permanence. Exhibits 4.1-1 through 4.1-6 summarize the criteria evaluation of each alternative as

¹¹ 6/11/03 Ecology correspondence to Eric Smalstig, GeoSyntec Consultants, and follow-up Ecology correspondence with Jay Manning, Esq., Brown Reavis & Manning, PLLC.

further discussed in this section¹². Exhibit 4.1-7 summarizes the cost estimate results for the six alternatives for the three cost scenarios described in Section 3.2.3.2.5.

The engineering layouts of each alternative are presented in Exhibits 4.3-1, 4.4-1, 4.5-1, 4.6-1, 4.7-1, and 4.8-1. The layout and work elements for the alternatives are conceptual. The layouts are intended only for the purpose of illustration and are not meant as final design layouts. Ecology will draft the CAP following FSTR finalization.

4.2 Common Components

4.2.1 General

Although each of the six alternatives uses a different technical approach to remediate the Site, they share certain components. Specifically, each alternative includes institutional controls and compliance monitoring. These components are described once, under Alternative 1, and referenced in Alternatives 2 through 6.

4.2.2 Institutional Controls

Institutional controls are non-engineered mitigation measures that reduce the potential for human exposure to contaminated media. Institutional controls include:

- **Fencing** – restricts access to contaminated media and limits the potential for exposure (implemented in 1996 on the Closed CKD Pile and maintenance continues).
- **Education (Warning Signs)** – warns people of the potential for exposure (implemented in 1996 and maintenance continues).

¹² See Nyer (1992) for a general discussion of alternative groundwater treatment technologies. EPA (1998) describes and compares alternative innovative groundwater treatment technologies including applications similar to those evaluated in this Revised dFSTR. EPA (2000) includes descriptions of case studies of groundwater remediation including sites and technologies that involve issues and processes similar to those addressed in this Revised dFSTR.

- **Restrictive Covenants** – where appropriate, Lehigh may file restrictive covenants noting specific conditions (e.g., high pH groundwater) and prohibiting certain uses.

4.2.3 Compliance Monitoring

Each of the alternatives includes provisions for compliance monitoring. Compliance monitoring has three components: protection monitoring, performance monitoring, and confirmation monitoring. To demonstrate protection monitoring, Lehigh will prepare worker health and safety plans and standard operating procedures. Performance monitoring consists of monitoring groundwater quality by using wells downgradient of the treatment systems. To demonstrate compliance with cleanup levels, groundwater monitoring wells will be located at the POC.

Lehigh has proposed cleanup levels for groundwater based on the beneficial use of Sullivan Creek (Sullivan Creek is considered a source of potable water, and groundwater flows into Sullivan Creek). As discussed above, Lehigh has proposed a conditional POC for groundwater between the treatment system of the various alternatives and Sullivan Creek. Ecology will locate the official POC in the CAP. Each of the alternatives evaluated in this FS process incorporates treatment-based remedies. There is inherent variability involved in operating engineered treatment systems. The method of evaluating compliance with cleanup standards will be established during development of the monitoring program defined in the CAP and design phases of the project, and ultimately approved by Ecology. Lehigh will report monitoring results to Ecology regularly, pursuant to provisions of the CAP and/or Consent Decree developed for the Site.

4.3 Permeable Treatment Wall (PTW)

4.3.1 PTW-Alternative Description

4.3.1.1 General

Alternative #1 – Permeable Treatment Wall (PTW) is a largely in situ technology that uses carbon dioxide diffusion into the CKD-affected groundwater to decrease pH of the groundwater. Treatment occurs within a trench excavated to intercept CKD-affected groundwater. The conceptual layout of this system is shown in Exhibit 4.3-1. Lehigh tested this technology in the pilot scale phase.

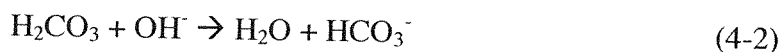
4.3.1.2 System Description

The PTW would be constructed to the east of State Route 31 and includes:

- Several trenches filled with coarse gravel, arranged in a line roughly parallel to Route 31 (approximately 1,500 cubic yards);
- Treatment trenches keyed into the underlying clay layer, which becomes the bottom of the treatment zone;
- Perforated plastic pipes buried in the treatment trench (approximately 3,000 lineal feet);
- Silicon tubing within the plastic pipes (approximately 60,000 lineal feet);
- A carbon dioxide source (approximately 28 tons of capacity);
- Mechanical and control systems;
- Control building;
- Barrier wall panels connecting the coarse gravel treatment zones;

- A limited number of groundwater extraction wells downgradient of the PTW to capture water that migrates through likely gaps in the treatment zone (See Section 4.3.1.3 for a more complete description); and
- The existing pilot carbon dioxide treatment system.

Exhibit 4.3-1 shows PTW components in plan and cross-sectional views, including a process diagram. Exhibit 4.3-1 does not show the limited number of groundwater extraction wells because their location and design would depend on the PTW construction. The PTW technology neutralizes pH in the CKD-affected groundwater. Carbon dioxide in the presence of water forms carbonic acid, which neutralizes hydroxide ions (the chemical cause for high pH in the Site groundwater) through the following reactions:



The decrease in pH reduces soluble arsenic in the groundwater. The arsenic forms insoluble complexes, returning to the aquifer solids (i.e., soil matrix) from which it originated. These chemical processes are described in detail in the Interim Progress Report [GeoSyntec, 2000].

The treatment zone in the PTW is approximately 400 ft long by 18 to 20 ft deep, with in situ carbon dioxide delivery systems. The treatment zones are in alignment with the current Pilot System, and they use the demonstrated and reliable treatment-based technology of the Pilot System installed in 2002¹³.

4.3.1.3 System Performance

The treatment zones of the PTW intercept CKD-affected groundwater¹⁴ as it flows downgradient of the Closed CKD Pile. The carbonic acid (from in situ diffusion of carbon dioxide into the groundwater) neutralizes the high pH water entering the treatment zones. As a result of the reduced pH, arsenic in solution precipitates out (i.e., form insoluble complexes) in the alluvial soil downgradient of the treatment zone. The groundwater treated in the treatment zone will meet cleanup levels for both pH and arsenic at a conditional POC located between the treatment zone and Sullivan Creek.

Lehigh evaluated a variety of neutralization agents to reduce the Site's groundwater pH, and determined that carbon dioxide is the most appropriate neutralization agent. In water, carbon dioxide forms carbonic acid, a weak acid. Other neutralization agents, such as hydrochloric acid, sulfuric acid, nitric acid, phosphoric acid and organic acids, have disadvantages with respect to system performance, including: storage and handling requirements for strong acids, over acidification potential, heat generation, production of regulated daughter compounds (e.g., chloride, sulfate, nitrate, phosphate), nutrient loading on Sullivan Creek (e.g., nitrogen, phosphorus), and further reducing redox potential, E_h , in situ. Reducing E_h would not result in arsenic precipitation and could cause the mobilization of other undesirable mineral constituents. The Pilot System has demonstrated that carbon dioxide treatment systems perform successfully at the Site by lowering pH, generally increasing E_h , and precipitating arsenic.

Because of certain design constraints of the diffusion tubing and physical limitations of the alignment, the PTW includes several treatment zone units, or segments (i.e., panels). Each of the treatment zone units is keyed into the low-permeability clay layer underlying the Site. Barrier panels, installed between the PTW segments and constructed of low-permeability material, divert untreated CKD-affected groundwater to the PTW treatment panels. Gaps in the treatment zone may occur due to

¹³ See EPA (1999a through c) for a general description of the design, installation, and general performance of reactive barriers, which are similar in many ways to the PTW alternative.

¹⁴ See EPA (1993) for a description of the performance of Passive Treatments Walls, a technology that is similar to that used in PTW. This reference also provides an exhaustive comparison of alternative remediation technologies.

construction challenges, such as limited visibility while installing system components under groundwater, the tendency of the thick plastic components to bend, and potentially not treating in the targeted location. Groundwater extraction wells downgradient of the treatment panels capture the groundwater that escapes treatment through the gaps in the treatment zone. Extracted groundwater can be treated aboveground and discharged into Sullivan Creek or routed back to the treatment zone. To avoid pump and treat (P&T) treatment residuals, the Revised dFSTR assumes that escaped groundwater will be routed to the treatment zone.

The change in pH in the treatment zone will precipitate a variety of minerals, in addition to arsenic minerals such as carbonates and silicates. Arsenic is a relatively small component of the groundwater that contains other dissolved solids. PTW treatment precipitates the arsenic as a small fraction of the overall mineral precipitate matrix. Treatment process modeling and stoichiometric calculations predict that arsenic will not accumulate in concentrations that exceed dangerous waste levels.

4.3.1.4 Construction Schedule

PTW design, contracting, and procurement requires approximately eight months. If required, approximately two months are needed to obtain regulatory approval for floodplain construction. PTW installation requires approximately five to six months. This estimated timeframe does not account for construction during inclement weather or winter conditions. The winter temperatures and hours of daylight in Metaline Falls adversely affect installation of the PTW, specifically the excavation of the trench, insertion of the perforated pipe into the treatment trench and construction of the barrier walls. Although possible, construction of PTW during the winter months is not advisable.

4.3.2 PTW-Protect Human Health and the Environment

The PTW will protect human health and the environment for the following reasons:

- ***Groundwater Quality.*** The PTW meets MTCA groundwater cleanup levels at a conditional POC. The Site-specific bench and pilot scale treatability studies [GeoSyntec, 2000, 2002, 2003a, and 2003b] demonstrated that this alternative effectively treats CKD-affected groundwater.
- ***ARAR Compliance.*** The PTW complies with ARARs.
- ***Institutional Controls.*** Lehigh will use institutional controls as described in Section 4.2.2.

4.3.3 PTW-Comply With Cleanup Standards

The Site-specific PTW bench scale and Pilot System test results established that this technology will meet cleanup standards assumed for the purposes of the Revised dFSTR, as follows:

- ***Cleanup Levels (CLs).*** The proposed groundwater cleanup levels for the Site are pH between 6.5 and 8.5, and maximum arsenic concentration of 5.0 ppb.
- ***Point of Compliance (POC).*** Lehigh proposes a conditional POC for groundwater at a point downgradient of the PTW treatment zone and upgradient of Sullivan Creek (Exhibit 4.3-1).

4.3.4 PTW-Comply With Applicable Federal and State Laws

The PTW complies with ARARs. Exhibit 3.2-1 presents a summary of ARARs that apply to this alternative.

4.3.5 PTW-Provide for Compliance Monitoring

Lehigh will provide compliance monitoring as outlined in Section 3.2.2.7. Lehigh will perform worker and public safety protection monitoring during construction when workers may be exposed to CKD-affected water and when the construction activities may disturb public areas (e.g., transportation on public streets). For performance and confirmational monitoring, Lehigh will use groundwater wells installed in accessible locations at the proposed conditional POC for groundwater. Standard groundwater monitoring wells will document the cleanup of the groundwater and demonstrate compliance with cleanup levels at the POC.

4.3.6 PTW-Use Permanent Solution to the Maximum Extent Practical

4.3.6.1 Introduction

This element for selection of cleanup actions requires consideration of the criteria used in the disproportionate cost analysis (WAC 173-340-360(3)). Each criterion in the disproportionate cost analysis is discussed below.

4.3.6.2 PTW-Protectiveness

As described in Section 4.3.2, PTW protects human health and the environment because it meets groundwater cleanup levels at a conditional groundwater POC. In addition, it complies with applicable state and federal laws.

4.3.6.3 PTW-Permanence

Permanent Solution. PTW is not a permanent solution. PTW requires maintenance, continual operation, and repairs, as needed, for an indefinite time period.

Permanence. PTW exhibits a high degree of permanence because it is a treatment-based technology that decreases pH and reduces the solubility (mobility) and toxicity of arsenic, obviating further groundwater treatment at the POC. In addition, it generates no treatment residuals¹⁵ that require future management and/or disposal. However, PTW will not prevent the generation of high-pH groundwater at the Closed CKD Pile.

4.3.6.4 PTW-Cost

The estimated present value cost to design and install a PTW is approximately \$2.1 million (US \$2005)¹⁶ (see Exhibit 4.3-2). The estimated annual operating and maintenance cost is approximately \$150,000. Hence, the present value of this alternative for 30 years at an annual discount rate of seven percent is approximately \$4.3 million. Actual costs may vary depending on the details of the final PTW system design and implementation procedures. Exhibit 4.1-7 includes the estimated costs of the six alternatives for the three scenarios described in Section 3.2.3.2.5 (See Appendix E).

4.3.6.5 PTW-Effectiveness Over the Long Term

Based on the past performance of the Pilot System, Lehigh has a high degree of confidence that PTW will be effective over the long term. Lehigh will operate and maintain the PTW as long as necessary to maintain compliance with cleanup levels at the point of compliance. Lehigh also will provide a financial assurance mechanism to cover the long-term operation and maintenance. PTW components could be added or decommissioned as needed, and could be replaced, as necessary (with some difficulty

¹⁵ A general term adopted here to designate treatment-produced material or by-product (e.g., treatment solids), generated by this or other processes, that will have to be stored, potentially further treated, transported from the Site, and ultimately disposed of at an appropriate disposal facility.

¹⁶ See EPA (2001) for a detailed discussion of the comparative costs and benefits of Permeable Reactive Walls (which are similar to the PTW) and Pump and Treat systems. Unless otherwise indicated, all costs are US \$ 2005.

due to the in situ nature of many of the PTW components). As such, the PTW will be effective over the long term.

4.3.6.6 PTW-Management of Short-Term Risks

There are few short-term risks associated with PTW. During construction of the PTW, workers may be exposed for a short time to high pH water, but this risk is common to each of the alternatives evaluated. The potential exposure to high pH water occurs while the treatment trench is open, allowing the CKD-affected groundwater to fill the treatment zone. Workers must take care when using heavy equipment and re-locating utility lines, including the municipal water line trending along the Sullivan Creek side of State Route 31, potential utilities to the existing building, a potential septic tank and associated features related to the existing building, and portions of stormwater conveyance pipe between the north culvert and Sullivan Creek. The risks posed are manageable with good construction safety practices. Construction and initial operation of the Pilot System created no significant short-term risk to workers or to the environment. Similarly, installation and operation of the PTW will also involve no significant construction or operation risks.

Construction during the winter months may increase the short-term risks associated with PTW. Since the trenching operation is performed in saturated conditions, short or dim daylight periods would pose additional safety concerns for workers. The winter conditions in Metaline Falls affect certain components of the PTW installation, specifically the perforated pipe installation in the treatment trench. Although possible, construction of PTW during the winter months is not advisable.

4.3.6.7 PTW-Technical and Administrative Implementability

4.3.6.7.1 *Technical Implementability*

Construction of several components is difficult in the winter months. The Pilot System installation demonstrated that the PTW is technically implementable during other times of the year.

4.3.6.7.2 *Administrative Implementability*

The PTW is administratively implementable. PTW does not require any Federal permit to discharge treated groundwater or to work near Sullivan Creek, although a local floodplain construction approval may be required. PTW produces no treatment residual that requires management. Lehigh owns all of the property needed to construct PTW.

4.3.6.8 PTW-Consideration of Public Concerns

The public will be given an opportunity to review and comment on the dFSTR. Ecology will consider all public comments before finalizing the dFSTR.

4.3.7 **PTW-Provide a Reasonable Restoration Time Frame**

Lehigh has proposed a conditional POC because PTW will not meet cleanup levels throughout the entire Site. It is difficult to precisely estimate when groundwater downgradient of the PTW will meet the cleanup levels for pH and arsenic at the conditional POC. However, the performance and confirmational monitoring components allow Lehigh and Ecology to monitor progress toward meeting groundwater restoration. The PTW will operate indefinitely to maintain compliance with cleanup standards.

The PTW will achieve compliance with groundwater cleanup levels at a conditional POC in approximately the same time frame as other alternatives evaluated in this Revised dFSTR. The detailed design phase will more fully evaluate the restoration time frame for the PTW.

4.3.8 PTW-Consider Public Concerns

The public will be given an opportunity to review and comment on the dFSTR. Ecology will consider all public comments before finalizing the dFSTR.

4.3.9 PTW-Prevent Domestic Use of CKD-Affected Groundwater

Lehigh will institute restrictive covenants to preclude domestic use of the groundwater.

4.4 Groundwater Control (GWC)

4.4.1 GWC-Alternative Description

4.4.1.1 General

Alternative #2 – Groundwater Control (GWC) combines the existing in situ permeable treatment wall Pilot System with P&T components to extract, treat, and discharge groundwater into Sullivan Creek. The P&T component addresses the CKD-affected groundwater that is not treated by the Pilot System. This approach offers certain advantages over either remedy by itself. In particular, it offers the advantages of in situ treatment via the Pilot System, combined with the flexibility of P&T construction around certain obstacles (e.g., the toe of the slope below the residential area near Sullivan Creek) and expandability, as needed. For the P&T component, an aboveground treatment process uses carbon dioxide to neutralize the high pH and ferric chloride to precipitate arsenic. The GWC collects the P&T precipitate containing arsenic for off-site disposal. The GWC discharges treated water into Sullivan Creek in compliance with an NPDES permit. Exhibit 4.4.1 shows the conceptual layout of the GWC system.

4.4.1.2 System Description

A GWC system includes the following components:

- An approximately 80-foot long in situ treatment zone (the existing Pilot System). No new panels are added.
- Groundwater extraction wells (approximately 16) to capture affected groundwater to the north and south of the Pilot System and pump it to a centralized, above-ground treatment system prior to discharge. The P&T components are described below.

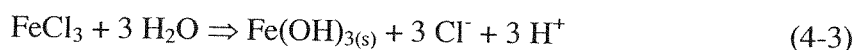
Because P&T is a proven and commonly used technology¹⁷, P&T is well-documented. The wealth of literature about P&T technology provides Lehigh abundant information to design, install, and operate an effective P&T system. A P&T system at the Site includes the following components:

- Groundwater extraction wells and collection manifold system;
- Above-ground treatment system;
- Discharge piping; and
- Waste storage area for temporary storage of treatment residuals pending transport off-site for disposal.

Exhibit 4.4-1 shows GWC components in plan and cross-sectional views. A conceptual process flow diagram is also included in the exhibit. Within the treatment

¹⁷ See EPA (1997), which states that “A common approach to deal with contaminated ground water is to extract the contaminated water and treat it at the surface prior to discharge...”. Keeley (1989) states that “One of the most commonly used ground-water remediation technologies is to pump contaminated water to the surface for treatment.” See also EPA (1996). The Wisconsin Department of Natural Resources (WDNR – 1993) provides detailed information about pump and treat test technologies. Ecology has approved several cleanup actions that include covering the source and treating downgradient groundwater with pump and treat technology.

system carbon dioxide forms carbonic acid in the presence of the CKD-affected water, which neutralizes the hydroxide ion (the chemical cause for high pH in the Site groundwater) through the reactions 4-1 and 4-2 presented in Section 4.3.1.2. As described in section 4.3.1.3, Lehigh selected carbon dioxide as the primary neutralizing agent to reduce the pH to levels that are conducive to ferric chloride (FeCl_3) treatment. FeCl_3 is commonly used as a coagulant in water treatment processes to remove colloidal metals [Reynolds, 1982]. Preliminary calculations show that a relatively small dosage (approximately 30 to 50 mg/L) of FeCl_3 is needed to achieve the proposed arsenic cleanup level. When mixed with water, FeCl_3 decomposes to yield hydrochloric acid and forms a dense, rapid settling floc composed mainly of ferric hydroxide, $\text{Fe}(\text{OH})_3$:



Since the H^+ reaction products are limited, the relatively small FeCl_3 dosage will not cause a significant change in the pH of the water. Lehigh will monitor the water's pH as part of the treatment process to adjust the carbon dioxide and FeCl_3 dosages, as needed. The use of ferric chloride to treat groundwater has several advantages. As a common water treatment process, ferric chloride is well understood and readily available in large quantities. Because the literature shows that the process works well over a range of field conditions, Lehigh did not test ferric chloride on the Site groundwater. However, geochemical modeling results indicate that the ferric chloride will be effective at treating the Site groundwater.

As shown in Exhibit 4.4-1, the GWC has a network of approximately 16 groundwater extraction wells (approximately 15 to 20 feet deep) placed between State Route 31 and Sullivan Creek. Preliminary modeling suggests that each well will pump between two and four gallons per minute (gpm). The final design will set the actual number and location of wells. The final design will also address hydraulic interaction between the wells and Sullivan Creek. Preliminary calculations indicate that the capture zone of the wells extends downgradient only for tens of feet (less than 50 ft). Options for addressing the hydraulic interaction include reducing the groundwater extraction rate when Sullivan Creek is at high water levels to limit drawing Sullivan Creek water into the system. Although not contemplated as part of the GWC, Lehigh could later install an impermeable slurry wall between the extraction wells and Sullivan Creek if hydraulic interaction persisted. The total extracted volume of approximately 55 gpm is pumped into a collection header, leading to the on-site treatment facility. The system generates

an estimated 40 to 150 pounds per day of residual solids, depending on the CKD-affected groundwater influent chemical characteristics. Preliminary calculations and geochemical modeling predict that the residuals will not designate as dangerous waste. Following treatment described above, the treated water is discharged to Sullivan Creek under an NPDES permit. Treatment residuals are collected and transported off-site for disposal.

4.4.1.3 System Performance

The GWC system intercepts CKD-affected groundwater. The following explains how each primary component of the GWC system works together to achieve cleanup standards.

The Pilot System lowers the pH of the groundwater by diffusing carbon dioxide into the water. As a result of the reduced pH, arsenic in solution precipitates out in the soil downgradient of the Pilot System. The groundwater meets cleanup levels for pH and arsenic at a conditional POC between the Pilot System and Sullivan Creek.

The P&T components intercept CKD-affected groundwater as it flows downgradient of the Closed CKD Pile outside of the Pilot System treatment area, extract it with pumps, and treat it aboveground using carbon dioxide and ferric chloride. Carbon dioxide is the neutralization agent to lower pH, and ferric chloride precipitates the arsenic out of solution by forming insoluble complexes. See section 4.3.1.3 for the rationale Lehigh used to select carbon dioxide as the neutralizing agent. Section 4.4.1.2 provides details on the behavior of ferric chloride flocculent. Preliminary calculations show that the relatively small dosage of ferric chloride will not contribute significant dissolved chloride to the treated water stream.

The P&T components are between State Route 31 and Sullivan Creek to address the CKD-affected groundwater that is not treated by the Pilot System. Although the layout (see Exhibit 4.4-1) shows the P&T components adjacent to a portion of State Route 31, the alignment may change based on the Site conditions. An advantage of P&T is the flexibility to locate extraction points throughout the affected area, where they are most effective. P&T has added flexibility because Lehigh can optimize the location of extraction wells, based on performance monitoring results.

4.4.1.4 Construction Schedule

GWC design, contracting, and procurement requires approximately eight months. GWC permitting and obtaining regulatory approvals requires approximately six to nine months (see Exhibit 3.2-1 for the list of permits and regulatory approvals). GWC installation requires approximately three months. This estimated timeframe does not account for construction during inclement weather or winter conditions. Winter weather minimally affects the construction of GWC, so that time of year will not appreciably affect the schedule. However, construction of GWC during the winter months is not advisable.

4.4.2 GWC-Protect Human Health and the Environment

The GWC system will protect human health and the environment for the following reasons:

- ***Groundwater Quality.*** The GWC meets MTCA groundwater cleanup levels at a conditional POC.
- ***ARAR Compliance.*** GWC complies with ARARs.
- ***Institutional Controls.*** Lehigh will use institutional controls as described in Section 4.2.2.

4.4.3 GWC-Comply With Cleanup Standards

The GWC system complies with cleanup standards assumed for the purposes of the Revised dFSTR, as follows:

- ***Cleanup Levels (CLs).*** The proposed groundwater cleanup levels for the Site are pH between 6.5 and 8.5, and maximum arsenic concentration of 5.0 ppb.

- ***Point of Compliance (POC).*** Lehigh proposes a conditional POC for groundwater at a point between the GWC system and Sullivan Creek (Exhibit 4.4-1).

4.4.4 GWC-Comply With Applicable Federal and State Laws

The GWC complies with ARARs. Exhibit 3.2-1 presents a summary of ARARs that apply to this alternative.

Calculations show that treatment residuals generated by the P&T component will not designate as dangerous waste and will be managed in accordance with applicable solid waste regulations.

4.4.5 GWC-Provide for Compliance Monitoring

Lehigh will perform protection, performance, and confirmational monitoring as described in Section 4.3.5.

4.4.6 GWC-Use Permanent Solution to the Maximum Extent Practical

4.4.6.1 Introduction

This element for selection of cleanup actions requires consideration of the criteria used in the disproportionate cost analysis (WAC 173-340-360(3)). Each criterion in the disproportionate cost analysis is discussed below.

4.4.6.2 GWC-Protectiveness

As described in Section 4.4.2, GWC protects human health and the environment because it meets groundwater cleanup levels at a conditional groundwater POC. In addition, it complies with applicable state and federal laws. GWC will generate groundwater treatment residuals requiring management and off-site disposal.

4.4.6.3 GWC-Permanence

Permanent Solution. GWC is not a permanent solution. The Pilot System and P&T components require maintenance, operation, repairs, and replacement for the foreseeable future.

Permanence. The GWC system exhibits a high degree of permanence. It uses treatment-based technologies that obviate further groundwater treatment at the POC. The technology chemically neutralizes the high pH water, resulting in a permanent reduction in pH and lower solubility (mobility) and toxicity of arsenic. However, the process also produces treatment residuals requiring off-site management. According to WAC, the generation of treatment residuals does not affect the degree of permanence of this alternative. In addition, GWC will not prevent the generation of high-pH groundwater at the Closed CKD Pile.

4.4.6.4 GWC-Cost

The estimated present value cost to design and install a GWC is approximately \$1.1 million (US \$2005) (see Exhibit 4.4-2). The annual operating and maintenance cost is estimated to be approximately \$230,000. Hence, the present value of this alternative for 30 years at an annual discount rate of seven percent is approximately \$4.1 million. Actual costs may vary depending on the details of the final GWC system design and implementation procedures. Exhibit 4.1-7 includes the estimated costs of GWC for the three costing scenarios described in Section 3.2.3.2.5. See Appendix E for supporting information, including assumptions used in the cost analysis.

4.4.6.5 GWC-Effectiveness Over the Long Term

Based on the past performance of the Pilot System and the proven success of P&T, Lehigh has a high degree of confidence that GWC will be effective over the long term. Lehigh will operate, maintain, and replace the GWC as long as necessary to

maintain compliance with cleanup standards. Lehigh also will provide a financial assurance mechanism to cover long-term operation and maintenance. The P&T components are easy to add, remove, or re-locate over the long term. As such, the GWC will be effective over the long term.

4.4.6.6 GWC-Management of Short-Term Risks

The GWC has few short-term risks associated with the Pilot System or the P&T components. Workers will encounter a small amount of CKD-affected groundwater during well development. Workers also will use heavy equipment and re-locate utility lines. The risks are manageable with good construction safety practices. P&T is a proven technology with known and manageable construction and operation risks. P&T operation poses no significant risks other than those associated with the treatment residuals produced and handled during ongoing operation and maintenance of the system. As with the other alternatives, it is best to avoid construction during winter conditions in Metairie Falls.

4.4.6.7 GWC-Technical and Administrative Implementability

4.4.6.7.1 *Technical Implementability*

The P&T component is a proven technology and is technically implementable. Construction involves less earth-moving and subsurface work than any other alternative, so that P&T is less subject to seasonal weather constraints than other alternatives. The more innovative and challenging component, the Pilot System, is already installed and operating at the Site.

4.4.6.7.2 *Administrative Implementability*

All components of GWC are administratively implementable. Lehigh will obtain an NPDES permit to discharge the treated water into Sullivan Creek. See Exhibit 3.2-1, which shows the permits and approvals needed for GWC. Lehigh's preliminary

research suggests that GWC will meet the conditions connected with these permits and approvals. Lehigh owns all of the property needed to construct GWC.

4.4.6.8 GWC-Consideration of Public Concerns

The public will be given an opportunity to review and comment on the dFSTR. Ecology will consider all public comments before finalizing the dFSTR.

4.4.7 GWC-Provide a Reasonable Restoration Time Frame

Lehigh has proposed a conditional POC because GWC will not meet cleanup levels throughout the entire Site. It is difficult to precisely estimate when groundwater downgradient of the GWC will meet the cleanup levels for pH and arsenic at the conditional POC. However, the performance and confirmational monitoring components allow Lehigh and Ecology to monitor progress toward meeting groundwater restoration. The GWC will operate indefinitely to maintain compliance with cleanup standards.

The GWC will achieve compliance with groundwater cleanup levels at a conditional POC in approximately the same time frame as other alternatives evaluated in this Revised dFSTR. The detailed design phase will more fully evaluate the restoration time frame for the GWC.

4.4.8 GWC-Consider Public Concerns

The public will be given an opportunity to review and comment on the dFSTR. Ecology will consider all public comments before finalizing the dFSTR.

4.4.9 GWC-Prevent Domestic Use of CKD-Affected Groundwater

Measures to prevent domestic use of CKD-affected groundwater are discussed in Section 4.3.9.

4.5 Additional Source Control (ASC)

4.5.1 ASC-Alternative Description

4.5.1.1 General

Alternative #3 – Additional Source Control (ASC) diverts groundwater that flows around and into the Closed CKD Pile, reducing the amount of CKD-affected groundwater generated at the Site. ASC includes a low-permeability slurry wall that limits upgradient seepage water from entering the pile materials and a vertical dewatering system upgradient of the slurry wall that removes water that piles up against the upgradient side of the slurry wall. The dewatering system protects the wall, helps prevent re-activating the historic landslide by not allowing water to build up behind the slurry wall, and enhances the performance of the slurry wall. To treat CKD-affected water that continues to emanate from the Closed CKD Pile, ASC includes a downgradient P&T system. ASC discharges water into Sullivan Creek from the dewatering wells and treatment system under an NPDES permit. Exhibit 4.5.1 shows the conceptual layout of the ASC.

4.5.1.2 System Description

The ASC includes the following components:

- **Slurry Wall.** A slurry wall¹⁸ about 2 ft wide is constructed hydrogeologically upgradient of the Closed CKD Pile and in soils and water unaffected by CKD. The slurry wall alignment is approximately 1,600 ft long and generally parallel to the current surface water control features along the southwestern and western extent of the Closed CKD Pile. The slurry wall is approximately 40 to 120 ft deep and would key

¹⁸ See Xanthakos (1979) for a very detailed description of the design, construction, and performance of slurry walls. ASTM (1985) includes numerous papers on slurry wall design, construction, and performance.

into the low permeability glacial sediments (i.e., clay) that underlie the Site. The slurry wall is not constructed in one trench of approximately 1,600 ft in length. Trench installation occurs in segments, especially in the vicinity of the historic landslide where one long trench has the potential to trigger a landslide or other slope stability issues.

- ***Upgradient Groundwater/Seepage Control.*** A necessary component of the slurry wall system is a dewatering system. It consists of a series of between approximately 10 and 15 groundwater dewatering wells upgradient of the slurry wall, each pumping up to approximately 15 gallons per minute, and toe drains at either end of the slurry wall. The groundwater wells and toe drains will drain the existing landslide area to enhance slope stability during construction of the slurry wall. During operation, they will preclude the development of high groundwater hydraulic pressure behind the wall. Such pressure would allow water to penetrate or overflow the wall and migrate into the Closed CKD Pile. The clean water extracted from the wells is discharged into Sullivan Creek via overland flow through existing the Site's surface water control features. Land not currently owned by Lehigh will contain some of the upgradient groundwater/seepage control elements.
- ***Downgradient Groundwater Control.*** A downgradient P&T system will control and remediate affected groundwater. The P&T system is relatively flexible and easily modified over time as the slurry wall and upgradient groundwater/seepage control systems reduce the volume and the extent of the CKD-affected groundwater.

Exhibit 4.5-1 shows each of these components in plan and cross-sectional views.

4.5.1.3 System Performance

As explained above, the slurry wall and dewatering wells reduce the quantity of groundwater contacting the CKD by diverting groundwater around the pile.

However, seepage of high pH and arsenic-containing groundwater downgradient of the Closed CKD Pile will continue, due to the following factors:

- ***Transient Drainage¹⁹ from the Closed CKD Pile.*** Parts of the Closed CKD Pile are saturated. The saturated portions of the pile will continue to drain until the moisture content of the pile is in equilibrium with gravity drainage forces. GeoSyntec analyzed the Closed CKD Pile using finite element modeling techniques. The modeling results estimate that transient drainage will continue for decades, but that the rate will drop to approximately 10 percent of its current rate in 50 to 100 years [GeoSyntec, 2004].
- ***Slurry Wall Performance.*** The slurry wall will not eliminate groundwater contact with CKD. Consequently, affected groundwater will migrate from the pile, due to the following reasons:
 - ***Slurry Wall Seepage.*** Although slurry walls can be substantially less permeable than other soils at the Site, no slurry wall is truly impermeable²⁰. The Site conditions such as the slurry wall depth, the historic landslide, steep terrain, and segmented installation exacerbate permeability issues with the ASC slurry wall. Common practice achieves a hydraulic conductivity of about 10^{-7} cm/sec (i.e., water passes through the slurry wall material at this or greater rates depending on the hydraulic head on the slurry wall). In spite of even the highest construction standards, some imperfections may remain in the as-constructed slurry wall, especially at the depths envisioned for ASC. Upgradient

¹⁹ Transient drainage is described in DOE/AL (1999) as follows: "The term 'transient drainage' was used to differentiate short-term seepage from disposal embankments from long-term seepage, which was expected to occur at smaller rates than short-term seepage." See the numerous case histories regarding transient drainage considerations in complying with groundwater cleanup standards. Stein et al (2000) describe a case history for which they predict that transient drainage from a tailing pond would continue for 50 to 70 years after closure.

²⁰ See EPA (1998b) for a recent evaluation of the performance of engineered subsurface barriers, including slurry walls, at waste sites.

groundwater will seep through these imperfections and move through the CKD.

- Groundwater upwelling into the base of the Closed CKD Pile. The slurry wall will be keyed into the clay layer that exists under the Closed CKD Pile. Although the clay is relatively impermeable, it will not hydraulically isolate the upgradient and downgradient sides of the slurry wall. Water will continue to pass under the slurry wall, but at a significantly slower rate than water passes through that area currently. The groundwater elevation under the CKD will equilibrate with the water on the upgradient side of the slurry wall. Additionally, wet seasons will cause high groundwater elevations in the Holocene alluvium, upwelling into the CKD that overlies these alluvial materials.

Thus, ASC will reduce, but not eliminate, the amount of downgradient groundwater that requires treatment. A P&T system will treat the CKD-affected groundwater. As the downgradient groundwater quality improves, Lehigh will reduce the number of extraction wells in the P&T system. Once CKD saturation equilibrium is obtained and transient drainage ceases, a few groundwater extraction wells will operate indefinitely to treat affected groundwater arising from slurry wall imperfections and groundwater upwelling.

This evaluation assumes the placement of a slurry wall with supplemental dewatering to control as much of the source as possible. If, however, one wished to reduce the size of the wall, the information herein provides a basis for analysis of these lesser alternatives. With a lesser alternative comes reduced control, diminishing the benefits of the alternative. See Exhibit 4.5-2 and Appendix E for more detailed information on cost and assumptions.

4.5.1.4 Construction Schedule

ASC design, contracting, and procurement requires approximately eight months. ASC permitting and obtaining regulatory approvals requires approximately six months to one year (see Exhibit 3.2-1 for the list of permits and regulatory approvals).

ASC installation requires approximately seven months. This estimated timeframe does not account for construction during inclement weather or winter conditions. The winter conditions in Metaline Falls adversely affect installation of ASC, specifically slurry wall construction, dewatering well network and drainage installation, and some P&T elements. When working with time frames for tasks that last longer than six months, the construction schedule may bridge over into a second construction season. As explained earlier, it is not advisable to install components of the ASC during the winter.

4.5.2 ASC-Protect Human Health and the Environment

The ASC alternative protects human health and the environment for the following reasons:

- ***Groundwater Quality.*** The slurry wall and upgradient groundwater/seepage control components, combined with downgradient P&T components, will meet MTCA groundwater cleanup levels at a conditional POC.
- ***ARAR Compliance.*** ASC will comply with ARARs.
- ***Institutional Controls.*** Lehigh will use institutional controls as described in Section 4.2.2.

4.5.3 ASC-Comply With Cleanup Standards

The ASC will comply with cleanup standards assumed for the purposes of the Revised dFSTR, as follows:

- ***Cleanup Levels (CLs).*** The proposed groundwater cleanup levels for the Site are pH between 6.5 and 8.5, and maximum arsenic concentration of 5.0 ppb.

- ***Point of Compliance (POC).*** Lehigh proposes a conditional POC for groundwater between the P&T system components and Sullivan Creek (Exhibit 4.5-1).

4.5.4 ASC-Comply With Applicable Federal and State Laws

The ASC will comply with ARARs. A summary of ARARs that apply to this alternative is presented in Exhibit 3.2-1.

The slurry wall and upgradient groundwater/seepage control components alone will not achieve cleanup standards for reasons detailed in Section 4.5.1.3, but they would reduce the amount of water that the P&T components must treat. As discussed in previous sections, the P&T components will meet cleanup standards. Calculations show that treatment residuals generated by the P&T component will not designate as dangerous waste and will be managed in accordance with applicable solid waste regulations.

4.5.5 ASC-Provide for Compliance Monitoring

Lehigh will perform protection, performance, and confirmational monitoring as described in Section 4.3.5.

4.5.6 ASC-Use Permanent Solution to the Maximum Extent Practical

4.5.6.1 Introduction

This element for selection of cleanup actions requires consideration of the criteria used in the disproportionate cost analysis (WAC 173-340-360(3)). Each criterion in the disproportionate cost analysis is discussed below.

4.5.6.2 ASC-Protectiveness

As described in Section 4.5.2, ASC protects human health and the environment because it meets groundwater cleanup levels at a conditional groundwater POC. In addition, it complies with applicable state and federal laws. ASC will reduce the amount of CKD-affected groundwater flowing downgradient from the Closed CKD Pile. ASC involves short-term risks, especially due to construction in the historic landslide and on the Closed CKD Pile. ASC installation includes measures to reduce the potential for reactivating landslides or compromising the stability of the Closed CKD Pile. Because ASC incorporates P&T components, it will generate groundwater treatment residuals requiring management and off-site disposal.

4.5.6.3 ASC-Permanence

Permanent Solution. The ASC is not a permanent solution. The upgradient groundwater/seepage control components require continual operation and maintenance. The slurry wall will not stop all groundwater contact with CKD. The downgradient P&T components require maintenance, operation, repair, and replacement, as needed, for the foreseeable future.

Permanence. The ASC exhibits a higher degree of permanence than treatment technologies alone because it reduces releases from the Closed CKD Pile and treats groundwater affected by ongoing future releases from the Pile. The degree of permanence exhibited by each ASC component is as follows:

- ***Slurry Wall.*** Because the slurry wall reduces the volume of hazardous substances generated at the Site, it achieves a high degree of permanence. However, the slurry wall's performance may diminish over time. As with any geologic material, the materials of the slurry wall will change as a result of natural processes, including change of moisture content and the ongoing geomorphic changes such as deformation associated with historic landslides through which the slurry wall would be constructed.

- ***Groundwater Extraction Wells and Seepage Control Features.*** These have a degree of permanence because they help reduce the volume of hazardous substances generated at the Site.
- ***P&T.*** P&T exhibits a high degree of permanence. It uses treatment-based technologies that obviate further groundwater treatment at the POC. The technology chemically neutralizes the high pH water, resulting in a permanent reduction in pH and lower solubility and toxicity of arsenic. The process also produces treatment residuals requiring off-site management.

4.5.6.4 ASC-Cost

The estimated present value cost to design and install ASC would range from \$9.1 to \$14 million (US \$2005) (see Exhibit 4.5-2). The annual operating and maintenance cost is estimated to be approximately \$240,000. Hence, the present value of this alternative for 30 years at an annual discount rate of seven percent is estimated to range from \$12.3 to \$17.2 million. Actual costs may vary depending on the details of the final ASC system design and implementation procedures. Exhibit 4.1-7 includes the estimated costs of ASC for the three costing scenarios described in Section 3.2.3.2.3. See Appendix E for supporting information, including assumptions used in the cost analysis.

4.5.6.5 ASC-Effectiveness Over the Long Term

While the slurry wall will reduce the amount of groundwater entering the Closed CKD Pile, over time its performance may diminish. If that happens, this alternative will rely more heavily on P&T components to maintain compliance with cleanup standards. As explained in Section 4.4.1, the P&T components have proven to be successful. In addition, they are flexible, allowing adjustments in changing conditions. Thus, Lehigh has a high degree of certainty that the P&T components of ASC will be successful over the long term, but a lower degree of certainty with regard to the slurry wall component.

Lehigh will operate and maintain the ASC as long as necessary to maintain compliance with cleanup standards. Lehigh also will provide a financial assurance mechanism to cover long-term operation and maintenance.

4.5.6.6 ASC-Management of Short-Term Risks

The short-term risks associated with constructing the ASC include those commonly associated with extensive use of heavy construction equipment. Short-term risks also include the potential to reactivate the historical landslide to the south of the Closed CKD Pile, as well as slope stability concerns associated with heavy equipment working on or near the 2:1 (horizontal to vertical) slopes of the Closed CKD Pile. The risks posed are manageable with good construction safety practices, but earthwork in the area of the historic landslide requires extreme caution. Dewatering mitigates some of the concerns. Segmented installation to avoid opening long trenches that cause stability issues also mitigates some of the concerns. As with the other alternatives, it is best to avoid construction during winter conditions in Metaline Falls.

P&T is a proven technology with known and manageable construction and operation risks. There are no significant short-term risks involved in P&T construction.

4.5.6.7 ASC-Technical and Administrative Implementability

4.5.6.7.1 *Technical Implementability*

The ASC alternative uses proven technologies and is technically implementable. Construction involves significant earth-moving and subsurface work and construction techniques that are difficult in winter weather. While ASC construction is difficult in the winter months, ASC is technically implementable during other times of the year.